A

SHORT VIEW

OF

ELECTRICITY

WILSON

1780

A SHORT VIEW OF ELECTRICITY,

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M.DCC.LXXX.

To Mr. MOULTOU, *jun. of Geneva, F. R. S.*

AS the following little Tract was really undertaken to bring you acquainted with the ſubject of Electricity; at leaſt, ſo far as comes within the compaſs of my knowledge, I have endeavoured to attain that end in the plaineſt and ſimpleſt manner; without troubling you with the opinions of others, and perplexing your mind with an endleſs variety of experiments.

The aſſiſtance you have ſince been pleaſed to favour me with, in conſequence of the plan I purſued, by applying your mathematical abilities to theſe reſearches, is a conſiderable proof that my friendly endeavours have afforded you ſome ſatisfaction. On which account there appears to be a propriety in addreſſing this *Short View of Electricity* to you: and the rather, if I might hope that it would encourage you hereafter to treat this part of philoſophy in the ſame manner as Sir Iſaac Newton has done the great ſubjects in his *Principia*.

I am, SIR, with the greateſt reſpect,

Your moſt obliged humble ſervant,

B. WILSON.

A

SHORT VIEW

OF

ELECTRICITY.

General observations deduced from experiments.

1. ELECTRICAL effects ſeem to depend principally upon certain *properties* and *circumſtances* of that univerſal elaſtic fluid, or *æther*, deſcribed by *Sir Iſaac Newton*.

2. The earth, and all bodies upon it, as well as the air, (ſo far as hath yet been experienced) have naturally a certain quantity of this fluid appropriated to them: which, being extremely ſubtile and elaſtic, is liable to be diſturbed from a variety of cauſes; and when diſturbed, will be continually endeavouring to recover its natural ſtate.

3. Bodies are ſaid to be electrified, in the technical ſenſe, when the natural quantity of this fluid is, by any cauſe, either augmented or diminiſhed. In the former caſe they are ſaid to be electrified *plus*: in the latter, *minus*.

4. Two very light bodies of the ſame material, ſize, and ſhape, properly ſuſpended, and in their natural ſtate, (ſo far as reſpects the fluid contained in them) do not change their place, but continue at reſt.

5. Two ſimilar bodies equally electrified *plus*, that is, having *received* more of the fluid than naturally belongs to them, recede from each other.

6. Two ſimilar bodies equally electrified *minus*, that is, having *loſt* part of the fluid which naturally belonged to them, do alſo recede from each other.

7. Two ſimilar bodies, equally electrified, but in a contrary ſtate, that is, the one having *more* and the other *leſs* of the fluid than

than what belongs to them naturally, move towards each other.

8. Two ſimilar bodies, the one electrified and the other not, do alſo move towards each other; but not ſo ſenſibly.
9. All bodies *reſiſt* the paſſage of this fluid more or leſs.
10. Glaſs, amber, ſilk, &c. reſiſt more than air.
11. A greater quantity of air reſiſts more than a leſs quantity.
12. Air, in general, reſiſts more than metal, wood, ſtone, &c.
13. Surfaces, that are ſmooth and even, reſiſt more than points or acute angles.
14. In ſpace, void of groſs matter, vapour, or air, this fluid moves moſt freely.
15. All thoſe bodies, ſuch as metals, wood, ſtones, &c. through which this fluid is found to paſs freely, have been uſually called *conductors*.
16. And all thoſe bodies, ſuch as glaſs, amber, ſilk, &c. through which it does not ſo freely paſs, *non-conductors*.

In the following experiments the wood made uſe of, as a conductor, is of a cylindrical form, and ſupported by glaſs that is dry and free from duſt, fibres of down, &c.

Balls formed out of the pith of Elder, not larger than one fifteenth of an inch in diameter, and ſuſpended by very fine flaxen threads, (about two inches long) from the cylinder of wood, are the ſimilar light bodies alluded to in the 4th, and following obſervations.

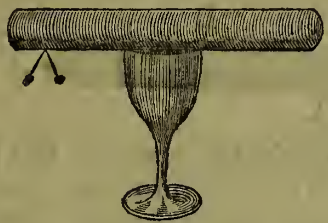
The *excited* (ſolid) *glaſs* cylinder, employed in theſe experiments, need only be about ſix or ſeven inches long, and three eighths of an inch in diameter.

Woollen cloth will excite this glaſs ſufficiently for moſt of the purpoſes deſigned in the following experiments.

EXPERIMENT I.

IN this experiment, the cylinder of wood A is rounded at both ends, and ſupported by a common wine glaſs; but to prevent its rolling off from the glaſs, it ſhould be made a little flat in one part.

Fig. 1.



EXCITED GLASS held acroſs, and over the middle of the wood, at a certain diſtance from it (which diſtance will depend upon the power of the glaſs) forces part of the *natural quantity* of the electric fluid, contained in the wood, into the balls; where it will accumulate to a certain degree.

As a proof of this, remove the glaſs quickly; then oppoſe it to the balls immediately, and they will recede from the glaſs. But this effect will continue only for a little time; becauſe the accumulated fluid in the balls, which was part of the natural quantity forced from the wood by the power of the glaſs in the firſt inſtance, returns again into the wood (and thus recovers its natural ſtate) ſoon after the glaſs is taken away.

This return of the fluid is ſomewhat ſlower in wood than in metal, becauſe the reſiſtance in the wood is ſomewhat greater.

EXPERIMENT II.

Repeat the experiment, and inſtead of removing the excited glaſs as before, *continue* it in its place. In this caſe the balls will continue to be repelled.

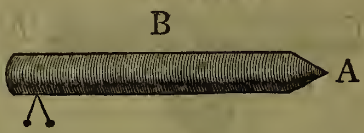
For if the power of the glaſs be ſufficient, at a given diſtance, to force a certain quantity of the fluid out of the wood into the balls; it muſt likewiſe be ſufficient to keep it there, that is, to

prevent its return, ſo long as the glaſs continues equally electrified, and at the ſame diſtance from the wood.

EXPERIMENT III.

In this experiment, the wood B is round at one end, and pointed at the other.

Fig. 2.



Excited glaſs, oppoſed very near to the point A, parts with a certain quantity of its fluid into the wood, threads, and balls. This additional quantity will continue therein for a conſiderable time, provided no cauſe interferes to diſturb and weaken it. But if ſuch a cauſe does interfere, and in a certain manner, the whole additional quantity may be diſcharged either *ſlowly*, or *ſuddenly*, according to the nature and form of the body employed to diſcharge it, the particular circumſtances of communication which this diſcharging body hath with the earth during the experiment, and the quickneſs or ſlowneſs of its approach.

When the ſame glaſs is oppoſed to the balls, and at a proper diſtance, they will continue to be repelled by it: and whatever additional quantity of fluid may be in the wood, threads, and balls, the point of a *pin* will not diſcharge it; provided it be fixed on one end of a ſtick of ſealing wax, and the head thereof be buried in the wax, and while the perſon who makes the experiment holds the wax by the contrary end: for no more of the fluid will eſcape into the pin than what will electrify it equally with the wood and balls, on account of the reſiſtance exerted by the wax. The quantity of fluid, therefore, which eſcapes into the pin, can only be proportional to its quantity of matter. But if the perſon holding the wax touches the pin with his finger, the additional fluid in the wood, &c. will, at that inſtant nearly, be diſcharged.

From hence it is manifeſt, that if a perſon, ſtanding upon the earth, could bring a very fine point towards a body electrified, (even

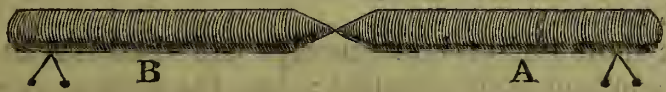
(even in the higheſt degree) *inſtantaneouſly*, the greateſt diſcharge would enſue at that moment. Now as this caſe is, in ſtrictneſs, impracticable, and as it requires *time* to bring the point ſufficiently near, the accumulated quantity muſt eſcape gradually in every inſtant of its approach. But the quicker ſuch approach is made, the more ſudden and violent will be the diſcharge.

Motion, therefore, is a circumſtance of great importance in experiments of this kind.

EXPERIMENT IV.

In this experiment the two bodies, A and B, are each of the ſame form as in experiment the third; and have their pointed ends placed near each other, or in contact.

FIG. 3.



Excited glaſs, held over A, (as in the firſt experiment) forces part of the fluid contained (naturally) in A into the balls hanging to it, and part into B: and if the two bodies A and B are immediately removed from each other, B will be found to have *more* fluid in it than belonged to it naturally, which it will retain for a time; and A will have *leſs*.

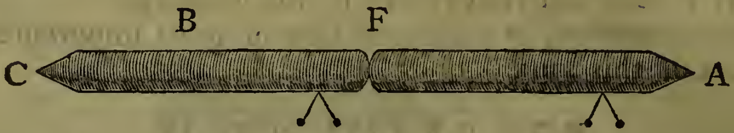
When A is ſeparated from B, the balls at A will move towards excited glaſs; and the balls at B will be repelled by it. Thoſe at A, therefore, as well as the wood, threads and balls, (having loſt part of their natural quantity) will be in a *minus* ſtate; and becauſe the balls at B, as likewiſe the wood and threads, have received an additional quantity, they will be in a *plus* ſtate. This is further manifeſt by bringing the two ends of A and B together again as they ſtood at firſt; for, immediately on doing this, the balls at the two extremities will no longer repel each other: becauſe the over-charge in B will diffuſe itſelf into A, and render the quantities in each equal.

EXPERIMENT

EXPERIMENT V.

In this experiment the two bodies, A and B, are each of the ſame form as before, but have their round ends oppoſed to each other,

FIG. 4.



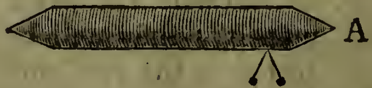
Excited glaſs, oppoſed very near to the end A, will part with a quantity of its accumulated fluid into A; and that quantity, by endeavouring to eſcape from A at the round end F, will force part of the natural quantity, contained in the ſimilar body B, out at the point C into the air: or, in other words, A will be electrified plus and B minus.

Separate thoſe bodies immediately, and the balls belonging to each will continue to be repelled: but the balls at A will recede from glaſs, and the balls at B will move towards it. Bring the bodies together and into contact, and the repulſion between the balls will ceaſe. Conſequently each body is now reſtored to the ſtate of its natural quantity: and, in the former part of the experiment, as much of the fluid as B loſt was equal to the quantity which A gained.

EXPERIMENT VI.

In this experiment the wood is pointed at each end.

FIG. 5.



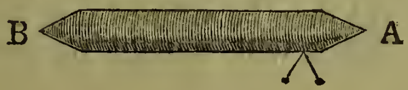
Excited glaſs, held over the middle of the body A, forces ſome part of the natural quantity within the wood into the balls; and ſome part out, at the two ends, into the air.

During this experiment the balls at A are repelled by glaſs; and are therefore in a plus ſtate. But after the excited glaſs is removed,

moved, in a very little time they change to a minus ſtate: becauſe the two ends of the wood, from the nature of their form, had ſuffered part of the natural quantity to eſcape into the air, while the glaſs was held over the wood. But now the glaſs being removed, the over-charge in the balls will of courſe return, and equally diffuſe itſelf into the wood again: and becauſe this over-charge, even with the addition of ſome part of the natural quantity belonging to the balls, is found inſufficient to balance the loſs ſuſtained, the wood, threads and balls muſt be in a minus ſtate.

EXPERIMENT VII.

Fig. 6.



Excited glaſs, held near the end B, parts with a quantity of fluid into it: but that quantity will be leſs than the quantity parted with into a body differently formed, as in experiment III.

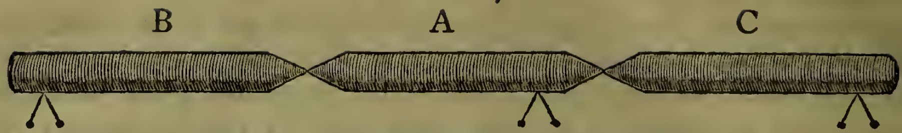
In this caſe, glaſs repels the balls, but the balls do not repel one another to ſo great a diſtance as in the third experiment: becauſe here the fluid eſcapes more readily at the two ends, from the nature of their form: whereas, in the other caſe, (experiment III.) one of the ends, being formed differently, reſiſts more, and conſequently ſuffers leſs of the fluid to eſcape by it.

EXPERIMENT VIII.

In this experiment three bodies, A, B, C, are placed in a line near to, or in contact with, each other. The middle body A is pointed at each end; but the extreme bodies B and C are rounded at one end, and pointed at the other; and have their pointed ends oppoſed to the pointed ends of A.

Fig. 7.

FIG. 7.



Excited glafs, held over A, forces out part of the natural quantity of fluid contained in A into B and C.

After the experiment feparate A from B and C immediately, and it will be found that glafs will caufe the balls at A to move towards it, and the balls at B and C to recede from it: when, therefore, thofe three bodies are brought again into their firft fituation, (properly) the balls hanging to B, A and C, will ceafe to repel each other; becaufe the over-charges (or accumulated quantities) in B and C will then be diffufed into A; and confequently each of the three bodies will contain no more than its natural quantity.

EXPERIMENT IX.

In this experiment the four pieces of wood, A, B, C, D, are each of them round at both ends, and in contact with each other.

FIG. 8.

Excited glafs, held over A, forces out part of the natural quantity contained in A into B; and the quantity received in B will force out part of the natural quantity contained in C into D.

The moment before the excited glafs is removed from A, feparate B and D from A and C; after which it will be found that A and C will be in a minus ftate, and B and D in a plus ftate: for, from the fame reafon that the excited glafs forced the fluid out of A into B, the increafe of fluid in B muft, (as the excited glafs did in the cafe of A) force the fluid out of C into D.

That

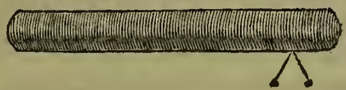
That the refpective bodies will be in thofe ftates, defcribed above, is manifeft from bringing the excited glafs towards rhe pith balls hanging to A B C and D: for thofe at A and C will move towards the glafs, and thofe at B and D will recede from it.

EXPERIMENT X.

In this experiment the body D is round at each end, as in the firft experiment.

FIG. 9.

D



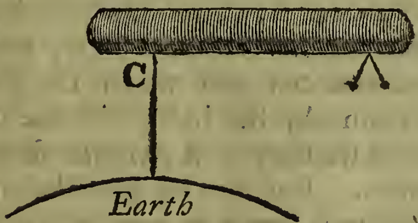
Excited glafs held over D, and *very near it*, parts with a fmall quantity of its accumulated fluid into D, where it will continue for a time.

Becaufe the refiftance at the two ends, arifing from their form, hinders, in a great meafure, any efcape of the fluid into the air, while the glafs is held over D; and that D has actually received more fluid, in this cafe, than what belongs to it naturally, appears from the balls being repelled by glafs.

EXPERIMENT XI.

FIG. 10.

A



Excited glafs held over A, during the time that any proper conductor (C) communicates with it and the earth, forces *part* of the fluid *out* of A into the conductor towards the earth; and renders

A *more minus* than if no ſuch communication with the earth was introduced.

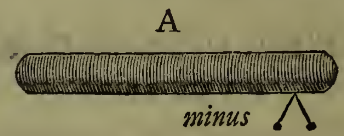
On removing the excited glaſs and conductor (C) at the ſame time, nay, even if the conductor be removed rather the laſt from A, the balls will be repelled, and move towards the glaſs when it is expoſed to them. If the experiment be made carefully, the diſtance between the balls may be obſerved to *increaſe* for a few moments after ſuch removal; that is, till the remaining part of the fluid in A becomes equally diffuſed therein.

Now, becauſe the balls are repelled to a greater diſtance, in this caſe, than when no communication with the earth interferes, it is a manifeſt proof, that air reſiſts the paſſage of this fluid more than groſſer matter.

If further proof be required for explaining the ſeveral effects produced in the preceding experiments, we need only purſue a little farther the laſt experiment, in which A was left in a *minus* ſtate; the communication with the earth being withdrawn, and the balls continuing to repel each other: For

EXPERIMENT XII.

FIG. II.



Excited glaſs, held over A, at 12 or 15 inches from it, and then moved gently nearer and nearer *towards* A, will cauſe the balls to approach nearer and nearer; and when the glaſs hath arrived to a certain diſtance from A, the balls will ſhew *no ſigns* of being electrified. In this ſtate they will *continue* ſo long as the glaſs continues in that ſtation. But if the glaſs be moved a little nearer towards A, the balls will begin to recede again from each other; and the nearer the glaſs is brought towards A, the *more* the balls will be repelled. In this laſt caſe, the balls are electrified plus, becauſe

becauſe they recede from glaſs: and they will continue in the ſame ſtate ſo long as the glaſs *continues* in the *ſame place*.

Now as theſe effects are produced by no other change of circumſtances, than merely moving the glaſs continually nearer towards A, the moving it back again, in the ſame manner, ought to produce the ſame effects, and leave the balls in the ſame minus ſtate they were found in at firſt.

Make the experiment, and it will ſucceed accordingly.

The minus electricity, obſerved from the repulſion of the balls, in the firſt inſtance, is rendered leſs, by the approach of the glaſs, which forces part of the natural quantity in the wood into the threads and balls. The nearer, therefore, the glaſs approaches to A, the more fluid is forced from A into them; conſequently, the repulſion of the balls muſt be leſs and leſs. When, therefore, the balls have received ſo much fluid from A, as equals the quantity they have loſt, their power of repelling ceaſes, and may, for the preſent, be conſidered as in their natural ſtate; the continuance of which ſtate depends upon the glaſs that cauſes it, becauſe the glaſs muſt continue to be held exactly in the ſame place: for the moment the glaſs is moved a little nearer towards A, (which is the ſecond inſtance) a little more of the fluid is forced from A into the balls; and whatever that quantity may be, it neceſſarily electrifies them plus. The moving the ſame glaſs, therefore, nearer and nearer to A, muſt, for the ſame reaſon, force more and more fluid from A into the balls; and thus the balls, from having their quantity increaſed, muſt be repelled more and more.

However trifling the preceding ſeries of experiments may appear to ſome electricians, the true philoſopher may probably view them in a different light; becauſe the reaſonings upon their ſeveral effects are, it is apprehended, equally applicable to other experiments made upon a larger ſcale.

As an inſtance, take one of the experiments that were made at the *Pantheon* with the *great cylinder*, when a leſſer one was joined to it, and when *motion* was introduced. By comparing that with the third of theſe experiments, their coincidence, in general, will

be manifeſt. For, in the *Pantheon* experiments, a *ſpark* was produced, at the end of the ſecond cylinder, by a *point* at *nine* inches diſtance, when it communicated with the earth and was *moved ſuddenly*. At the ſame inſtant (nearly) all the fluid, or, however, the greateſt part, was diſcharged: the ſpark obtained, therefore, was at a greater diſtance than when the ſame point was brought gradually towards the cylinder.

The caſe is very different with a different termination, though the other circumſtances continue the ſame. For when a *ball* of metal was properly put in the place of the point, and an equal motion given to it, the greateſt diſtance, at which a ſpark was produced, was only *ſix* inches. This difference of diſtance depended, therefore, upon the metal ball reſiſting the paſſage of the fluid more than the point; becauſe leſs of the fluid eſcaped by the ball than there did by the point, as appeared from the different *reſiduums* in the cylinders, that were obſerved immediately after the exploſions happened; there being a greater reſiduum when the ball had cauſed a ſpark, than when the point had done the ſame. So neceſſary is it, in all theſe caſes, to attend to the circumſtance of *motion* as well as that of *reſiſtance*.

Seeing that motion is of ſo much conſequence in experiments of this kind, a method may be contrived which will cauſe the greateſt diſcharge poſſible, from a body containing any given quantity of fluid, by interpoſing a proper ſubſtance (for example, glaſs or wax, ſufficiently broad and thick) between the end of the body propoſed to be charged, and the point or round end which is to cauſe the diſcharge; and that *without moving* either of thoſe ends in the leaſt.

For when thoſe extremities are brought to a convenient or certain diſtance from each other, and the body is afterwards charged, the removing ſuch interpoſed ſubſtance *ſuddenly* from between thoſe extremities (by ſome proper and ſimple contrivance) will cauſe the diſcharge almoſt inſtantaneouſly; and conſequently, the relative diſtances at which a point or round end will be ſtruck, with a given charge, may be more exactly aſcertained. On which account it appears

appears to be an experiment of ſome moment, and deſerves to be tried; as it is yet in diſpute whether a point or ſurface is ſtruck at the greateſt diſtance.*

If the contrivance, alluded to above, for removing the interpoſed body ſuddenly, ſhould conſiſt of a *ſpring* of any kind, no part thereof muſt interfere with the experiment, ſo as to reduce the charge in the leaſt, while ſuch ſpring is producing its effect. And becauſe the motion, which is to be given to the interpoſing ſubſtance, is propoſed to be *conſiderable*, there muſt be a cuſhion, or ſome other ſubſtitute, to counteract the force by which the interpoſed body is impelled.

* If the two extremities are ſharply pointed, the diſtance between them, at which the diſcharge happens, will, it is apprehended, be conſiderably greater than when the ſame ends have a ſpherical termination, of a given diameter.

THE preceding experiments having been made with *wood*, which is a conducting ſubſtance, it is now time to introduce others made with *glaſs*, which is uſually called a *non-conductor*.

But before theſe experiments are entered upon, it may be proper to obſerve, that there are ſome delicate circumſtances belonging to them, which, if not attended to, will miſlead the obſerver more than he may be aware of.

1. Whenever an experiment is to be made with glaſs, *as a conductor*, particular care muſt be taken that every part of it is in a natural ſtate, and conſequently undiſturbed by friction, or any other cauſe, except that of the air, which is unavoidable.
2. The pith balls employed ought to be ſuſpended by fine flaxen threads, three or four inches long; becauſe, the bringing excited glaſs near them, to examine their plus or minus ſtate, might otherwiſe interfere with the glaſs conductor and diſturb the experiment.
3. A greater or leſſer degree of power in the excited glaſs, will occaſion ſome differences in the effects produced by it.

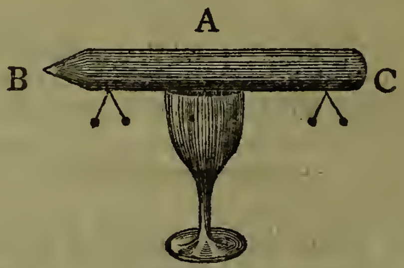
4. The

4. The glaſs conductor ought to have no bubbles or ſand-holes in it, particularly near its ſurface.
5. Breathing upon any part of the conductor ought alſo to be avoided.

EXPERIMENT XIII.

B, A, C, repreſents a ſolid cylinder of glaſs near three quarters of an inch in diameter, and about eight inches long; one end of which is rounded, and the other pointed.

FIG. 12.



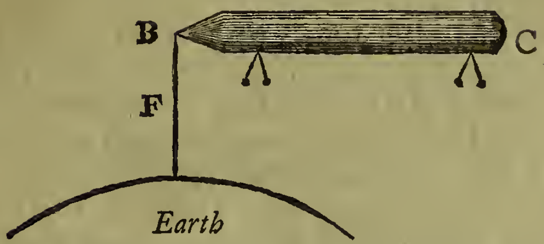
The ſame *excited glaſs*, as was employed in the preceding experiments, held at two inches or thereabout from the rounded end C, forces part of the natural quantity of fluid at that end towards the other; and after a time, (the excited glaſs being removed) the quantity ſo forced returns.

Oppoſe the excited glaſs to the balls at C, and they will move towards it; then oppoſe it to thoſe at B, and they will be repelled. And, becauſe the fluid meets with more reſiſtance in glaſs than in metal or wood, the motion of it will be ſlower; and therefore muſt take up ſome time before the accumulated quantity forced towards B can poſſibly return to the minus part at the end C.

EXPERIMENT

EXPERIMENT XIV.

FIG. 13.



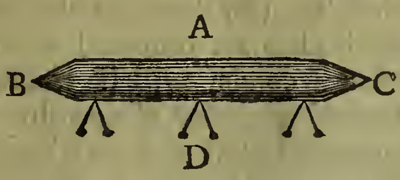
Repeat the laſt experiment, but with this difference; let there be a communication of metal (F) with the earth from the point B; and, after a few ſeconds, remove the communication and excited glaſs at the ſame time. When this is done the whole glaſs will be electrified minus.

For while the excited glaſs at the end C is forcing the natural quantity towards B, the communication (F) with the earth is conveying part of it off: and therefore when that communication and the excited glaſs are removed at the ſame time, the whole of the glaſs A muſt be more or leſs in a minus ſtate: that is, according to the quantity of fluid which eſcaped at the point B, through F, towards the earth during the continuance of the excited glaſs at C.

EXPERIMENT XV.

In this experiment the glaſs is pointed at each end.

FIG. 14.



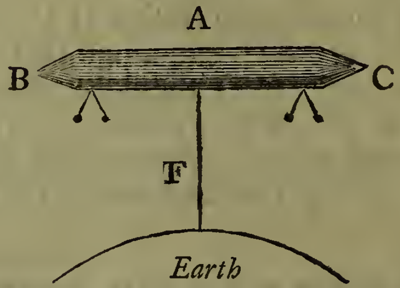
Excited glaſs, held over the middle of B C, forces that part of the natural quantity which is neareſt to A towards the two ends, and

and ſome of it into the air at the points B and C: in a little time afterwards the whole of B C, and all the balls, will be electrified minus.

That the excited glaſs forces part of the natural quantity from the middle towards the two ends, appears from the balls at B and C being repelled by glaſs: and that the middle has loſt part of its natural quantity, is manifeſt from the balls at D moving towards the glaſs. In the other caſe, where more time is neceſſary, the whole of B C is electrified minus: becauſe all the balls move towards excited glaſs; and therefore ſome part of the natural quantity muſt have eſcaped at the points: otherwiſe the whole glaſs and balls could not, in ſuch circumſtances, be in a minus ſtate.

EXPERIMENT XVI.

FIG. 15.



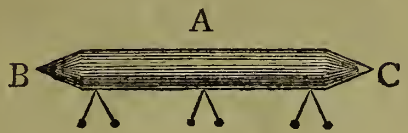
Excited glaſs, held over A, during the time that a metal conductor (F) communicates with any part near the middle of B C and the earth, forces part of the natural quantity out of the glaſs, near A, into the conductor (F) towards the earth; ſo that when the metal and excited glaſs are removed at the ſame time, the whole of B C, in a few ſeconds, will be electrified minus.

For part of the natural quantity eſcapes by the metal (F); and therefore, when the excited glaſs and metal are removed, the balls at the two ends will repel each other a little, and move towards excited glaſs. But when the whole of the remaining fluid in B C has had time to diffuſe itſelf equally throughout, the balls will repel

repel each other to a greater diſtance, and move towards the glaſs with more force.

EXPERIMENT XVII.

Fig. 16.

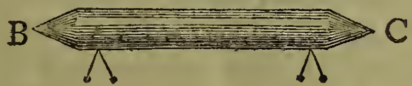


While the glaſs B C, and the balls hanging to it, continue in their minus ſtate, if the excited glaſs be again held over the middle for a few ſeconds, the two ends will be electrified plus, and the middle part will remain minus. But the plus effect at the two ends will continue for a little time only (after the excited glaſs is removed) and then the whole of B C will return to its minus ſtate again, as was the caſe in the laſt experiment.

The excited glaſs, in this caſe, forces more of the remaining fluid from the middle towards the two ends, therefore the balls hanging to thoſe ends will be repelled by glaſs; and the balls in the middle will be moved towards it. The greater quantities of fluid at thoſe ends muſt conſequently, in a little time, (that is, after the excited glaſs is removed,) diffuſe themſelves into the minus part again, and put the whole of B C into the ſame ſtate in which it was at firſt.

EXPERIMENT XVIII.

Fig. 17.



Excited glaſs, held at the end B and in contact with it, parts with ſome of its accumulated fluid into B; and the quantity admitted therein forces out ſome part of the natural quantity at the remote end C into the air: and when the quantity received at the end B has had time to diffuſe itſelf through the whole of B C, then all the balls will be repelled by glaſs.

That, during the experiment, ſome part of the natural quantity of the fluid in the glaſs cylinder B C eſcapes at the end C, appears from the effect which the excited glaſs hath upon the balls at C: becauſe their motion is not from, but towards, the glaſs. But when the quantity received at B has had time to diffuſe itſelf through B C, then the balls at both ends will be electrified plus.

EXPERIMENT XIX.

FIG. 18.

B  D

The ſame excited glaſs, held at about one inch diſtance from the end B of a ſolid cylinder of glaſs (B D) ſix feet long and about half an inch in diameter, will force part of the natural quantity of the fluid at the end B towards the remote end D. But in doing this, the natural quantity, belonging to the glaſs, will undergo ſeveral alterations; as appears from the effects which excited glaſs hath upon a number of balls ſuſpended at equal diſtances between B and D. In a little time thoſe alterations will be reverſed: that is, the parts of the glaſs that were electrified plus will become minus, and thoſe that were minus will be plus.

EXPERIMENT XX.

When the ſame excited glaſs is held at the end B, as before, but in contact with it (for a very little time) the additional fluid received at B will, in going towards D, cauſe ſeveral alterations in the denſity of the natural fluid contained in B D. But thoſe alterations of denſity will be the converſe to thoſe in the laſt experiment. And after a little time they will alſo be reverſed, like thoſe obſerved in the former caſe.

Whoever may be diſpoſed to repeat theſe two experiments, muſt not be ſurprized if, in a few trials, he ſhould not make them ſucceed in the manner here deſcribed: becauſe it is extremely difficult, and

and almoſt impoſſible, to find the ſame number of balls plus, and the ſame number minus, in each experiment. For a difference in the degree of power applied, or a difference in point of time allowed for the changes, as well as to obſerve the ſtate of each ball, make conſiderable differences in the effects. Theſe and other delicate circumſtances have been the reaſon for deſcribing the two laſt experiments in general terms. As to the cauſe of the alternate ſtates of the fluid in the whole length of B D, and the changes taking place afterwards, it may be comprehended from what has been obſerved in the preceding experiments.

Becauſe we have ſeen (by experiment 5, 9, 13, 17, and 18,) that whenever the fluid, contained within a body, becomes ſuddenly denſer in any one part, the fluid in the neighbouring parts, to a certain diſtance, will be rarer: and *vice verſâ*, whenever it is made ſuddenly rarer in any part, the fluid lying next to it becomes denſer. Whence it is manifeſt, that thoſe alternate variations of rarity and denſity, muſt, from the nature of an elaſtic fluid, continue to oſcilate many times backward and forward before the fluid can be at reſt. But after thoſe oſcilations are weakened to a certain degree, they muſt become imperceptible to the obſerver.

From theſe experiments it is alſo manifeſt, that the air ſurrounding any body electrified (when properly circumſtanced) muſt likewiſe be electrified, but in a contrary ſtate, to a certain diſtance; and beyond that, muſt undergo the like alternate changes to imperceptible diſtances.

EXPERIMENT XXI.

If inſtead of the glaſs cylinder, (employed as a conductor) there be put in its place a glaſs of a different ſhape; for example, a *plate* eight or ten inches ſquare, both ſides thereof, to a certain diſtance from the center, will be electrified plus, by oppoſing the excited glaſs towards the middle of one of them only, and at a little diſtance from it.

EXPERIMENT XXII.

On the contrary, the middle of the glafs, on both fides, will be electrified minus; provided the diftance between the excited glafs and the plate of glafs is confiderably increafed.

N. B. Inftead of oppofing the excited glafs (in the two laft experiments) to the plate of glafs, it will be found more convenient to oppofe the *round end* of a metal conductor, when it is properly electrified.

The difference of form, then, between a plate and cylinder of glafs, can make little or no difference in thofe general effects.

HAVING now produced a fufficient number of facts to fhew the nature of this fluid, and the conftant uniformity of its action, in glafs as well as wood (they differing only in the circumftance of refiftance) we may fafely venture to deduce from them fome obfervations that will be of ufe in explaining the Leyden experiment.

Obfervation 1. Whenever a given quantity of the electric fluid (which for the future will be expreffed by the word *power*) is brought within a certain diftance of the furface of a body, whether it be wood, metal, or glafs, it will force out part of the natural quantity of fluid belonging to that body, (and that the more readily if it communicates with the earth) and will alfo prevent its return, fo long as the power continues the fame, and at the fame diftance from the furface.

Obf. 2. The nearer, therefore, this power is brought to the furface of the fame body, the greater will be the effect produced by it.

Obf. 3. More time is required for the electric fluid to pafs through a given length, or thicknefs of glafs, than through metal or wood of the fame length or thicknefs.

Obf. 4. This difference of time, in the paffage of the fluid through glafs, metal, or wood, can arife from no other caufe than the different refiftances made by thofe fubftances.

Hence it appears, that if by any contrivance we can bring the power to, and depofit it at, the furface itfelf of a plate of glafs, (by diffufing it over a given quantity of that furface,) the fluid fo lodged muft, from having fo advantageous a fituation, act upon the natural quantity contained in the glafs with its greateft force. And confequently not only drive out the greateft quantity of the fluid naturally lying at the oppofite furface; but alfo continue to prevent the return of an equal quantity of fluid to fupply the lofs it had thus fuftained; and that fo long as the power lodged continues in its place.

But it is to be obferved, that no expulfion of the fluid can in any degree take place at the oppofite furface, unlefs the refiftance at that furface be fufficiently weakened (or, at leaft, in fome degree) by a proper communication with the earth.

A plate of glafs thus circumftanced, is, for the purpofe of experiment, the *Leyden phial.*

For the contrivance, alluded to above, means no more than that this plate fhould have an equal and partial coating of metal laid properly upon each furface. The one ferving to conduct the power immediately to the glafs, (fo far as the coating extends) and collect it there: and the other to carry off as readily fuch part of the natural quantity belonging to the glafs itfelf (at that furface) towards the earth, or towards any other equivalent fubftitute, as the power collected is able to drive away.

When a plate is thus charged, and as highly as it will admit, the removing of the coating cannot remove the charge from the glafs, becaufe it is depofited at, or near, the furface itfelf. Neither can the oppofite furface, which is in a contrary ftate at the fame time, receive a fimilar quantity of fluid from any other power (to fupply the lofs it has fuftained) unlefs at the time there be a removal of *that* in which the charge confifts: by reafon of the advantageous fituation of the diffufed charge which originally drove off and prevents the return of fuch natural quantity to the oppofite furface; as is evident from the 1ft and 2d of the laft obfervations.

And

And becauſe the reſiſtance, ariſing from the air, as well as that occaſioned by the ſubſtance of the glaſs itſelf, prevents a free communication between the two ſurfaces, any contrivance which will ſufficiently leſſen the reſiſtance between them, muſt neceſſarily ſuffer the charge to eſcape towards the other ſide of the glaſs, and reſtore the equilibrium. Conſequently, if no alteration takes place to leſſen the reſiſtance, the glaſs muſt continue in the ſame charged ſtate.

When a wire, or other convenient ſubſtance, is employed for this purpoſe, it is called the *circuit:* becauſe one end communicates with the coating on one ſurface; and the other with the oppoſite coating: for when this is properly made, an exploſion enſues, and the plate recovers its natural ſtate; though not abſolutely ſo, there being in many inſtances ſome little remainder.

A ſlow and imperceptible diſcharge may be produced by moiſt air, vapour of different kinds, and other conducting matter in the form of vapour, when properly applied, and in ſufficient quantity, ſo as to extend itſelf to both ſurfaces.

Another contrivance to leſſen the reſiſtance, and thereby cauſe the diſcharge, is to reduce the thickneſs of the glaſs itſelf in any particular part, where the charge is to be given. Becauſe, if it be made ſufficiently thin, the power exerted at the charged ſurface will, in this caſe, force its way through the ſubſtance of the thinneſt part, and break the glaſs to come at the oppoſite ſurface, and ſupply the natural quantity of fluid it had loſt.

Hence we may now underſtand, why increaſing the thickneſs of the plate increaſes the reſiſtance: and therefore, why a plate of glaſs, beyond a certain thickneſs, cannot be charged at all by the ſame degree of power.

That all bodies reſiſt the paſſage of the fluid more or leſs has been fully proved: but from what cauſe this reſiſtance ariſes hath not yet appeared.

ACCORDING to Sir Iſaac Newton, and the experiments hitherto made, a certain elaſtic medium (ſimilar, except in denſity,

ſity, to the fluid we are treating of) is ſuppoſed to be ſpread over the ſurface of all bodies, extending to a certain exceedingly ſmall diſtance from them; which medium is more or leſs denſe, according to the nature of the body it ſurrounds.

On thoſe accounts it is continually liable to be diſturbed from a variety of cauſes.

The rings of colours produced by preſſing the object-glaſſes of two long teleſcopes together, taken notice of by the ſame great obſerver of nature, and the idea he entertained that ſuch a medium, as deſcribed above, does actually ſurround the ſurface of all bodies, were ſufficient inducements for trying, whether, by the aſſiſtance of thoſe coloured rings, ſome kind of alteration in the medium might not be obſerved to take place, when the glaſſes themſelves were charged with the electric fluid in a certain manner.

PREPARATION.

A well poliſhed plate of glaſs, (about 12 inches ſquare, properly guarded with a border of ſealing wax all round the extremities on both ſides, near three inches broad) was well charged like the Leyden phial. After which the two coatings were carefully removed.

Another glaſs, plain on one ſide and a little convex on the other, (four inches and three quarters in diameter, and ſufficiently thin, being alſo guarded a little more than half an inch on both ſides round the extremity with ſealing wax) was likewiſe charged, the plain ſide plus and the *convex minus*. After which the two coatings were alſo carefully removed.

EXPERIMENT XXIII.

When the convex ſurface, thus charged *minus*, was gently laid upon the *minus* ſurface of the large plate of glaſs, the weight itſelf of the plano-convex, without any other preſſure, was ſufficient to cauſe a *diſtinct* appearance of the coloured rings: and the central ſpot exhibited a *darkiſh blue colour*. And notwithſtanding this general appearance varied, upon any the leaſt change of accidental

dental circumſtances, yet the mean diameter of the ſpot ſeemed to be about the twentieth part of an inch.

EXPERIMENT XXIV.

After charging thoſe glaſſes again as before, except that now the convex ſide was in a *plus* ſtate, the experiment was carefully repeated, but in a contrary way; for the convex ſide charged *plus* lay upon the *plus* ſurface of the large plate of glaſs: and though the weight or preſſure of the glaſs was the ſame, as in the firſt caſe, yet there was a ſenſible difference; in the general appearance at leaſt: for the coloured rings were *leſs diſtinct*, and the central ſpot appeared of a *yellowiſh* or *greeniſh colour*.

Upon repeating this experiment it was obſerved, in one or two inſtances, that the ſpot apeared of a fine red colour: and in other trials, there was no appearance of any ſpot or coloured rings whatſoever.

Hence it appears, that the glaſſes were *nearer* to each other when in the minus ſtate in the 21ſt experiment: and that the ſurfaces ſtood at a *greater* diſtance from each other when in the plus ſtate in the 22d experiment; the preſſure in both experiments being the ſame.

Query, Does it not follow from hence, that the medium on the ſurfaces of the two glaſſes had its natural limit extended, or contracted, according to the nature of the charge, agreeable to the repreſentations in fig. 21 and 22? Unleſs thoſe differences, in the appearance of the rings, ſhould have ariſen from any unevenneſs of the ſurfaces. For the two ſurfaces of the ſquare plate of glaſs, though finely poliſhed, were not ground parallel to each other: which, to have removed all doubt, they ought to have been.

It is material to obſerve here, that at the end of each of the preceding experiments with the ſquare plane and plano-convex glaſſes, it was found that they continued to retain the greater part of their reſpective charges.

EXPERIMENT

EXPERIMENT XXV.

When the glaſſes were laid on each other, as before, but without any charge in either, the preſſure ariſing from the weight of the plano-convex, was ſufficient to produce the rings, but not ſo diſtinctly, as in the 21ſt experiment; yet more ſenſibly than in the 22d.

IN ORDER to convey a more clear idea of the manner in which this medium is ſpread over the ſurfaces; and how it is affected by different circumſtances, it has been thought not improper to repreſent the different ſtates of the medium, in the caſe of glaſs particularly, (when it is not, and when it is, diſturbed) by the following figures.

FIG. 19.

A B C D reprefents the edge, or fection of a plate of glafs, in its natural or undifturbed ftate.

a b, *a b*, the limit of the medium fpread on each fide of the furface A B.

d c, *d c*, the limit of the medium fpread on each fide of the furface C D.

G G G G, the natural ftate of the fluid which lays between the medium *a b* below A B, and the medium *d c* above C D.

This medium is fuppofed by Sir *Ifaac Newton*, in his letter to Mr. *Boyle*, (and fince that in his optics) to be rareft at the furface A B (or C D) from whence, on each fide, it increafes in denfity continually and regularly to a certain exceedingly fmall diftance. Beyond which the denfity decreafes as regularly to an equal diftance; that is, to *a b* (or *d c*): fo that the denfeft part of the medium lies exactly in the middle between A B and *a b*, above and below; and the rareft part exactly in the middle between *a b* above A B and *a b* below it: or, as was obferved above, at the furface itfelf A B.

FIG. 20.

A B C D reprefents the fame glafs, and in the fame ftate, as in fig. 19.

t t, the upper coating of metal.

k k, the under coating of metal.

m, the conductor to communicate the fluid to the upper coating *t t*.

n, a metallic communication between the under coating *k k*, and the earth, to conduct the fluid to the earth when driven out from the under furface by the power exerted at the upper furface.

Being thus circumftanced, the glafs is properly prepared for making the *Leyden* experiment.

FIG. 21.

Reprefents the fame glafs when its medium is difturbed, *or charged*, with the electric fluid.

p p, the part at the furface A B where the charge being lodged or depofited, produces the effect of a plus electricity.

m m, the part at the furface C D, which, being deprived of part of its natural quantity of fluid by the power at *p p*, produces the effect of a minus electricity.

FIG. 22.

A B C D reprefents the fame glafs, as in fig. 21. in its charged ftate, but without the coatings.

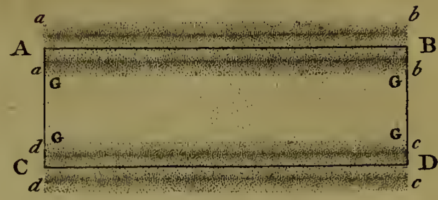


Fig. 19.

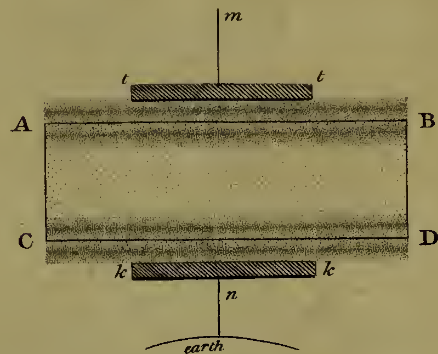


Fig. 20.

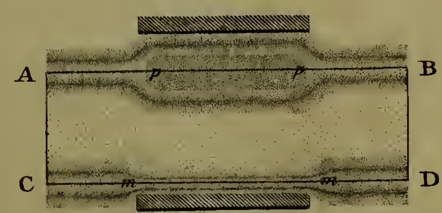


Fig. 21.

Fig. 22.

BASIRE Sc.

THIS intereſting experiment, though ſo common, hath not as yet, perhaps, been explained to the ſatisfaction of the philoſopher. All the authors who have written upon it having (as it is apprehended) confined their attention chiefly to the meer reſult of experiments, rather than to the ſtate of the fluid contained within the ſubſtance and at the ſurface of glaſs.

A ſolution, deduced from Sir Iſaac Newton's opinion, touching the natural ſtate of the ſurface of bodies deſcribed in fig. 19, and the conſequences to be drawn from certain alterations cauſed therein, will probably be acceptable to thoſe at leaſt, who embrace his doctrines.

FIG. 23.

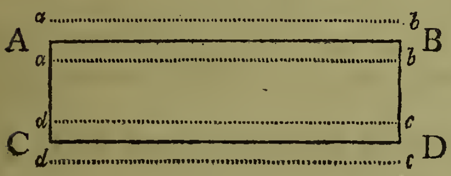
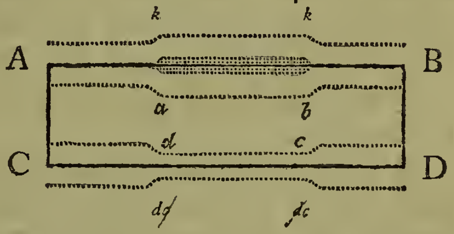


FIG. 24.



When the ſurface of glaſs A B (fig. 23.) has received a certain quantity of electric fluid, as repreſented in fig. 24. the medium, which on each ſide of A B is ſuppoſed to be limitted by *a b* and *a b*, muſt be driven on each ſide farther from the ſurface A B than it was before, that is to *k k* and *a b*; and therefore muſt preſs the natural fluid which lies between the internal limits *a b* and *d c*, againſt the oppoſite medium belonging to the ſurface C D, and ſuppoſed to be limitted by *d c* and *d c*. But the fluid naturally belonging to the glaſs being thus preſſed, muſt puſh the limit *d c*, and force it nearer to the ſurface C D, than it was in its undiſturbed ſtate. And then the fluid, which naturally belongs to C D, being alſo preſſed, muſt neceſſarily, in part at leaſt, be driven out of the glaſs. For without ſuch effect taking place, the limit *d c* cannot change its ſituation, or be brought nearer to the ſurface C D. But if *d c* be not brought nearer to C D, neither will *a b* be moved farther from the ſurface A B, which it before was proved to be.

But it is neceſſary to open a paſſage for this fluid to eſcape from one ſurface while the other is charging: becauſe, if there be no ſuch paſſage, the glaſs cannot be charged in the *Leyden* manner at all; on account of the reſiſtance ariſing from the natural fluid belonging to the glaſs, and the medium itſelf at the under ſurface.

The diſcharging of the *Leyden* phial then being (as obſerved before) only the reſtoring of the equilibrium in the fluid belonging to the glaſs, the effect, produced by the ſhock of the fluid through the conductor which is employed to reſtore the equilibrium, muſt be attributed to the reſiſtance of the glaſs itſelf: conſequently the fluid cannot, on account of that reſiſtance, be accelerated in going through the conductor. Therefore, whatever difference is perceived in the violence of the ſhock through conductors of different lengths, that difference ſhould be attributed to the reſiſtance the electric fluid meets with in going from one end of ſuch conductor to the other.

AFTER the preceding explanation of the ſtate of the fluid in the *Leyden* experiment, it will be proper to ſhew the ſtate of it within the ſubſtance of a common conductor when it is charged. We have therefore added the following Theorem reſpecting that ſtate, and the particular part of the conductor which the charge principally occupies.

THEOREM.

If a ſolid cylinder of metal is charged with electric fluid, I ſay, the fluid contained therein will be denſer at the ſurface than in any part nearer its axis.

If it be ſuppoſed otherwiſe, and the fluid to be equally denſe throughout the whole cylinder, then the effect produced, by diſcharging it, would be proportional to the quantiy of matter contained in the cylinder. But by experiment it is found, that a hollow cylinder, of a ſimilar ſubſtance, length, and diameter, with the former, and which will contain only the thouſandth part of its ſolid matter, will produce very nearly the ſame effect as ſuch a

ſolid

ſolid cylinder; and not, as might be expected, the thouſandth part of it only. The particles of the fluid, therefore, contained in the ſolid one, muſt be in a ſtate extremely rare, compared with thoſe at the ſurface.

IT has been remarked, that bodies terminated with points, receive, or part with the electric fluid more readily than rounded ones. This being a fact of ſome conſequence, we ſhall attempt to give the reaſon of it upon the preceding principles.

WHEN a body is charged with electric fluid, I ſay, that if the ſurface thereof is terminated by a ſharp end, it will part with that fluid more eaſily than if it is terminated by a round ſurface.

FIG. 25.

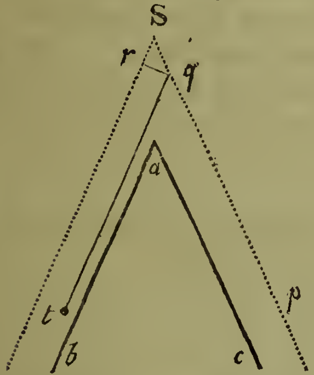
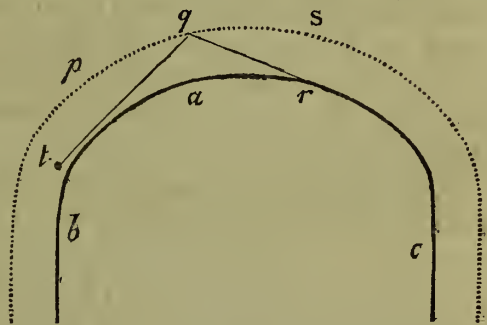


FIG. 26.



Let an acute angle *b a c* repreſent the termination of the body in queſtion; *t* a particle of the fluid lying between the ſurface of the body and its medium; and let *tq* be the direction of the particle. When the particle *t* arrives at *q*, it muſt be refracted outwards, or reflected inwards, in the direction of *qr*, which makes the angle *rqs* equal to the angle *tqp*. But in the caſe of the ſharp end, the reflection of the particle in the direction *qr* is more perpendicular to *rs* than *tq* is to *qp*; and by conſequence muſt contribute to produce in the particle a fitter diſpoſition to refraction in that ſtate than when it moved in the firſt direction.

But

But in the caſe of the round ſurface, the reflection cannot produce any ſuch advantage, becauſe the particle is always reflected inwards without changing the direction for one more advantageous.

Therefore the ſharp end muſt part with the fluid ſooner, becauſe in all the caſes of reflections the particles are reflected according to the directions that are always more advantageous to a refraction; which is not the caſe with the round end.

Upon ACCELERATION.

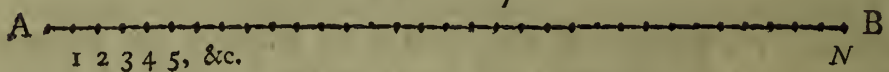
THE experiments at the *Pantheon*, which were intended to ſhew the acceleration of the fluid, having been objected to by many who have not ſufficiently attended to the known properties of the elaſtic fluid, it has been thought proper here to eſtabliſh this very material point upon mathematical principles, with a view to put an end to all farther diſputes on the ſubject.

But before this is done, it may be neceſſary to mention a material fact that was omitted in the account of thoſe experiments, which is this,

The ſhock, received at the *middle* of the long wire, was *conſiderably leſs* than that which was received at either end.

THEOREM.

FIG. 27.



Let A B repreſent a cylinder of a given diameter, and ſuppoſe this cylinder charged with the electric fluid. I ſay, if all the particles of this fluid are moved at the ſame inſtant towards A, the effect produced, by the ſhock of this fluid, at A, will be nearly proportional to the ſquare of A B.

For the total effect at A is equal to the ſum of the effect of each particle contained in the cylinder A B. And the effect of each particle being proportional to its velocity, the total effect at A will

will be proportional to the ſum of all the velocities. But ſince the fluid is ſuppoſed nearly perfectly elaſtic, all the particles will arrive at A nearly at the ſame inſtant. Then the velocity of each particle will be proportional to the diſtance from the place it ſets out: and the total effect at A will be proportional to the ſum of all thoſe diſtances.

But all thoſe diſtances are expreſſed by the following numbers, 1, 2, 3, 4, 5, &c. .... N (N, expreſſing the length A B) in an arithmetical progreſſion (ſee Fig. 27.) Then the ſum of all the diſtances will be expreſſed by the ſum of the arithmetical progreſſion 1, 2, 3, 4, 5, &c. .... N, and the effect at A will be proportional to this ſum, that is to ſay, to N^2. or A B^2. Q. E. D.

COROLLARY.

We may demonſtrate in a ſimilar manner that the reſiſtance which the fluid meets with in its paſſage through the cylinder A B, in going to A, is proportional to A B^2.

COR. 2.

Then, generally, the total effect produced by the diſcharge at A (the reſiſtance being allowed for) is proportional to A B^2.

Concerning LIMITED ACCELERATION.

IN the foregoing Theorem the body receiving the ſhock hath been conſidered as in communication with the Earth, and conſequently in the ſituation proper to produce a complete diſcharge; and therefore a perfect acceleration.

It is now neceſſary that we conſider the caſe in which the body, being *inſulated*, does not receive the whole diſcharge from the cylinder, but only ſo much of the fluid as is neceſſary to reſtore he equilibrium between the body and the cylinder: this was fully proved by Experiment III. From which it is plain, that the quantity of electric fluid which the body upon the diſcharge receives, being limited, the diſtance alſo, whence the electrical particles compoſing that quantity ſets out, muſt be limi-

ted,

ted; and therefore the acceleration of the particles, together with the effect produced, will likewiſe be limited.

In the following analyſis it is propoſed to determine that limit; and at the ſame time to ſhew the law obſerved in the effects produced by the diſcharge from different cylinders of equal diameters, but indeterminate lengths, upon an inſulated body.

A

K

LET K repreſent a cylinder ſimilar to that in the preceding Theorem, that is to ſay, of a diameter very ſmall in compariſon of its length; a wire for example.

Let A be the body inſulated which is to receive the ſhock from the cylinder K. Now as we may not be able immediately to compare the quantities of the fluid which, after the ſhock, are contained in the body A and the cylinder K; we will ſuppoſe a certain cylinder *a* having its diameter equal to that of K, and its capacity, with reſpect to the electrical fluid, equal to the capacity of A, to be inſulated, and in the place of A to receive the diſcharge from the cylinder K: ſo that, whatever ſhall hereafter be proved reſpecting the cylinder *a* may be with truth applicable to the body A.

Firſt. Suppoſe *a* equal to *k*, and let *a* receive the ſhock.

a K

The two cylinders being inſulated muſt, after the ſhock, be in equilibrio; and being equal, *a* muſt have received half of the whole of the electrical fluid which, before the ſhock, was contained in K. The effect therefore produced, by the diſcharge from the cylinder K upon the inſulated body A, will be equal to the effect which would be produced by the diſcharge of a cylinder

der of half the length of the cylinder K upon the ſame body A not inſulated. Conſequently (and by what hath been proved in the preceding Theorem) the effect produced by the cylinder K upon the inſulated body *A* is but the fourth part of the effect produced by the ſame cylinder K upon the body A not inſulated.

This is a particular caſe; and is only here introduced, as being the moſt ſimple, and conſequently the moſt eaſy for computation. In what follows the propoſition is as general as poſſible.

Secondly. Suppoſe now the cylinder K to be of any given length, and that length expreſſed by n times the length of a.

The two cylinders, as before, being inſulated, a will, upon the diſcharge, receive no more of the fluid than what is neceſſary to reſtore the equilibrium; that is, $\frac{1}{n+1}$th part of the whole. For the whole quantity contained in K is expreſſed by n; and conſequently the quantity of fluid received by a (or A) upon the ſhock, is properly expreſſed by $\frac{1}{n+1}$. And hence it follows, that the effect produced by the diſcharge from the cylinder K, upon the inſulated body A, is equal to the effect produced upon the ſame body A, not inſulated, by the diſcharge of a cylinder of the ſame diameter with the cylinder K; but whoſe length is to the length of the cylinder a as $\frac{1}{n+1}$ is to 1.

EXAMPLE.

The length of the cylinder a being expreſſed by 1, and the quantity of fluid, which a is capable of receiving, being conſequently expreſſed by 1, alſo; if now the length of the cylinder K be ſucceſſively expreſſed by the numbers 1, 2, 3, 4, 5, ... n, the quantity of electrical fluid received after the diſcharge by the

infulated body A, will be refpectively expreffed by the numbers $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{4}$, $\frac{4}{5}$ . . . . . $\frac{n}{n+1}$: this laft being a general expreffion.

LIMIT.

If the length of the cylinder K be fuppofed to become infinite; that is, if the number n be indefinitely great; we fhall then have $\frac{n}{n+1}$ equal to 1; and the quantity of electric fluid received by the infulated body A, will confequently be expreffed by 1. And fo, the effect produced by the difcharge of the boundlefs cylinder K upon the infulated body A, will be equal to the effect produced by the difcharge from a cylinder equal to a upon the body A not infulated.

GENERAL CONCLUSION.

Whatever may be the length or the diameter of a cylinder, and with whatever quantity of electrical fluid it be charged; the fhock received from fuch a cylinder, by a body infulated, is limited: and that limit depends entirely upon the body which receives the fhock.

COROLLARY.

1. So that a man *infulated* receiving the fhock from a wire three miles in length may hardly perceive any effect: whereas the fame man *not infulated* may probably be killed by the fhock from the fame cylinder equally charged.

2. The lefs the infulated body is, which receives the difcharge, the lefs is the acceleration.

IN the *Leyden* experiment, the furface of glafs, which is in a minus ftate, cannot receive any undetermined quantity of the fluid, but muft receive, from the other furface, only half of the excefs.

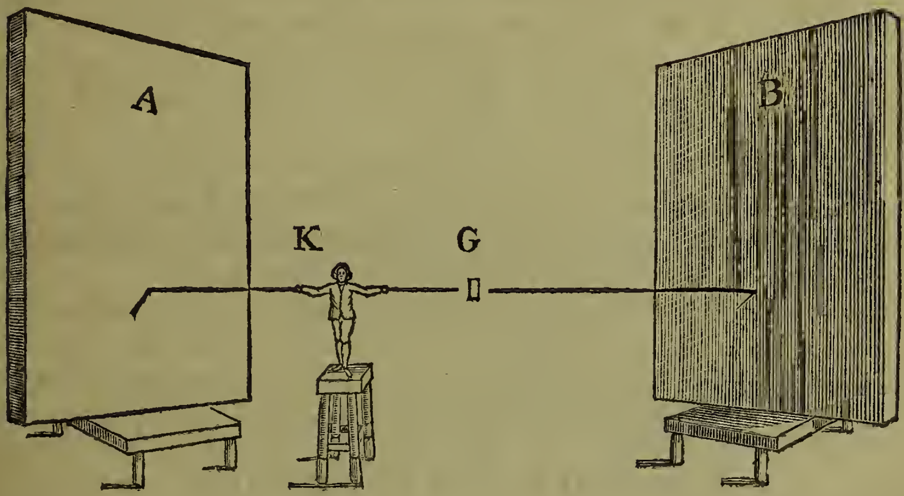
The *Leyden* phial then, is in the fame cafe with the man who is infulated. Confequently (in fuch circumftances) there can be no acceleration.

Therefore the effect produced by the *Leyden* charge muft be proportional to the quantity of the fluid. And confequently, in glafs

glaſs of the ſame thickneſs, proportional to the quantity of ſurface.

And becauſe the ſhock produced by the *Leyden* phial depends upon the two ſurfaces being electrified one plus and the other minus, it is manifeſt, that wherever the like plus and minus electricity can be introduced, and to a certain degree, the effect will be the ſame without any glaſs at all.

FIG. 28.



Inſtead, therefore, of having thoſe contrary powers ſo very near together as in glaſs, let two ſimilar, and ſufficiently large, ſurfaces A and B (fig. 28.) of any metallic ſubſtance properly guarded at the edges with ſealing wax, and inſulated, be placed parallel and at a given diſtance from each other; whether five, or twenty-five, feet is equally indifferent. And let a perſon, alſo inſulated, ſtanding between thoſe plates, for example at K, communicate by wires from one plate to the other; except at G, where a given interval muſt be left for interpoſing the proper ſubſtance alluded to in pages 12 and 13, which is to interrupt ſuch communication. If the plates, in thoſe circumſtances, are equally electrified, one plus and the other minus; and the interpoſed body G be removed *ſuddenly*, the

 perſon,

perſon, at K, will receive a ſhock like that which is received from a charged glaſs of a certain ſize.

Hence it appears, that the violence of the ſhock will be proportional to the ſize of thoſe metallic ſurfaces: and therefore, to equal the charge of any *Leyden* phial, or number of phials, thoſe ſurfaces muſt be increaſed accordingly.

WE have already proved, that there is no acceleration in the caſe of the *Leyden* phial, and conſequently, that the ſhock is proportional to the quantity of ſurface. Now as it hath been demonſtrated (by the Theorem upon acceleration) that the effect produced with a cylinder of a given diameter (very ſmall compared with its length, a wire for example) is proportional to the the ſquare of its length; it follows

That if we expreſs the effect produced from a wire of a certain length, by a certain number of ſquare feet of *Leyden* phial, we ſhall be able to determine the number of ſquare feet that will produce an equal effect with a wire of any length.

Let n repreſent the length of a wire which produces the effect of the *Leyden* phial, containing in ſquare feet the number a. I ſay, that a wire of any length $q \times n$, will produce an effect equal to the effect produced by $q^2 \times a$, ſquare feet of the *Leyden* phial.

DEMONSTRATION.

The effect produced by the wire n is to the effect produced by the wire $q \times n$, as $n^2 : q^2 n^2$. But the effect produced by n is equal to the effect produced by the number a in ſquare feet of *Leyden* phial, and $n^2 : q^2 n^2 :: a : q^2 \times a$. Therefore the effect produced by the wire $q \times n$ is equal to the effect produced by the number of $q^2 \times a$, of ſquare feet of *Leyden* phial. Q. E. D.

EXAMPLE.

If we ſuppoſe the effect produced (in the *Pantheon*) by a wire of one mile in length, is equal to the effect produced by two

ſquare

ſquare feet (only) of *Leyden* phial, how many ſquare feet are there neceſſary to produce the effect of a wire of 18 miles in length?

Then $n = 1 \;.\; a = 2 \;.\; q = 18$.

Conſequently $q^2. \times a = 18^2 \times 2$.

$= 324 \times 2 = 648$.

It is neceſſary, therefore, to employ 648 ſquare feet of *Leyden* phial to produce the effect of a wire 18 miles long, in which the fluid is accelerated; and not 30 ſquare feet, as was mentioned in a paper lately read in the Royal Society.

SO FAR we have conſidered this elaſtic fluid, ſimply as ſuch, without any regard to other matter that generally accompanies it, and produces a great variety of ſingular appearances, ſuch as lightning, and other luminous phœnomena.

Of whatever kind this matter may be, which experiment ſhews to be intimately connected with the elaſtic fluid, there is ſufficient reaſon to conclude, that it conſiſts of particles not near ſo ſubtile as thoſe which compoſe the fluid itſelf.

But whether it be *phlogiſton* or a combination of *phlogiſton* with other matter; and whether the property in air of lighting up this matter into ſparks, &c. is a ſeparate and diſtinct principle, muſt be left to future inveſtigation.

F4 blank